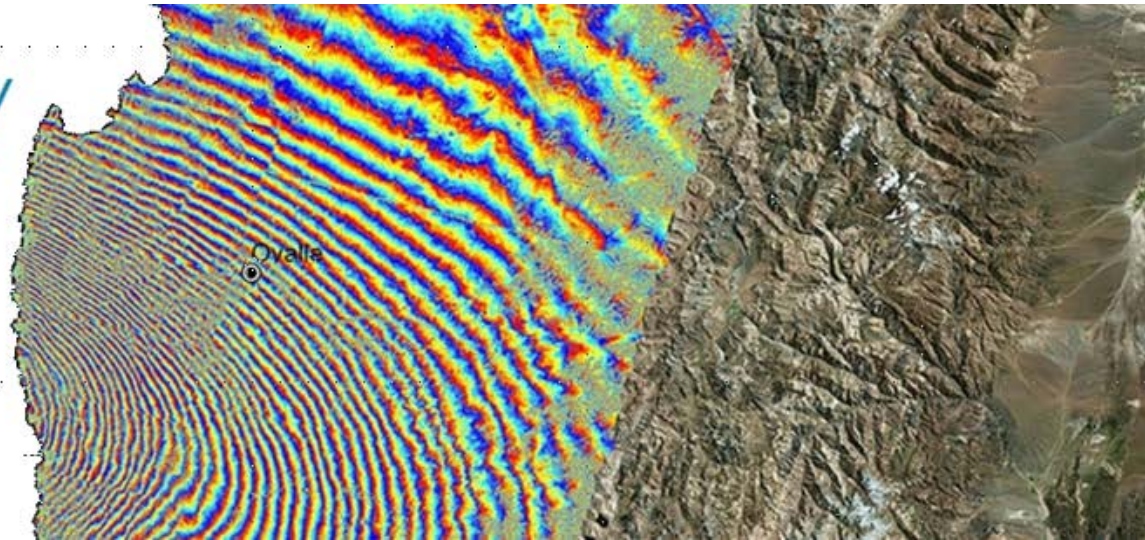
Leveraging different Copernicus access Hubs and National Mirror Sites for large scale interferometric processors to monitor geohazards

Dr. Charalampos Kontoes
Research Director IAASARS/NOA

geObservatory

IAASARS



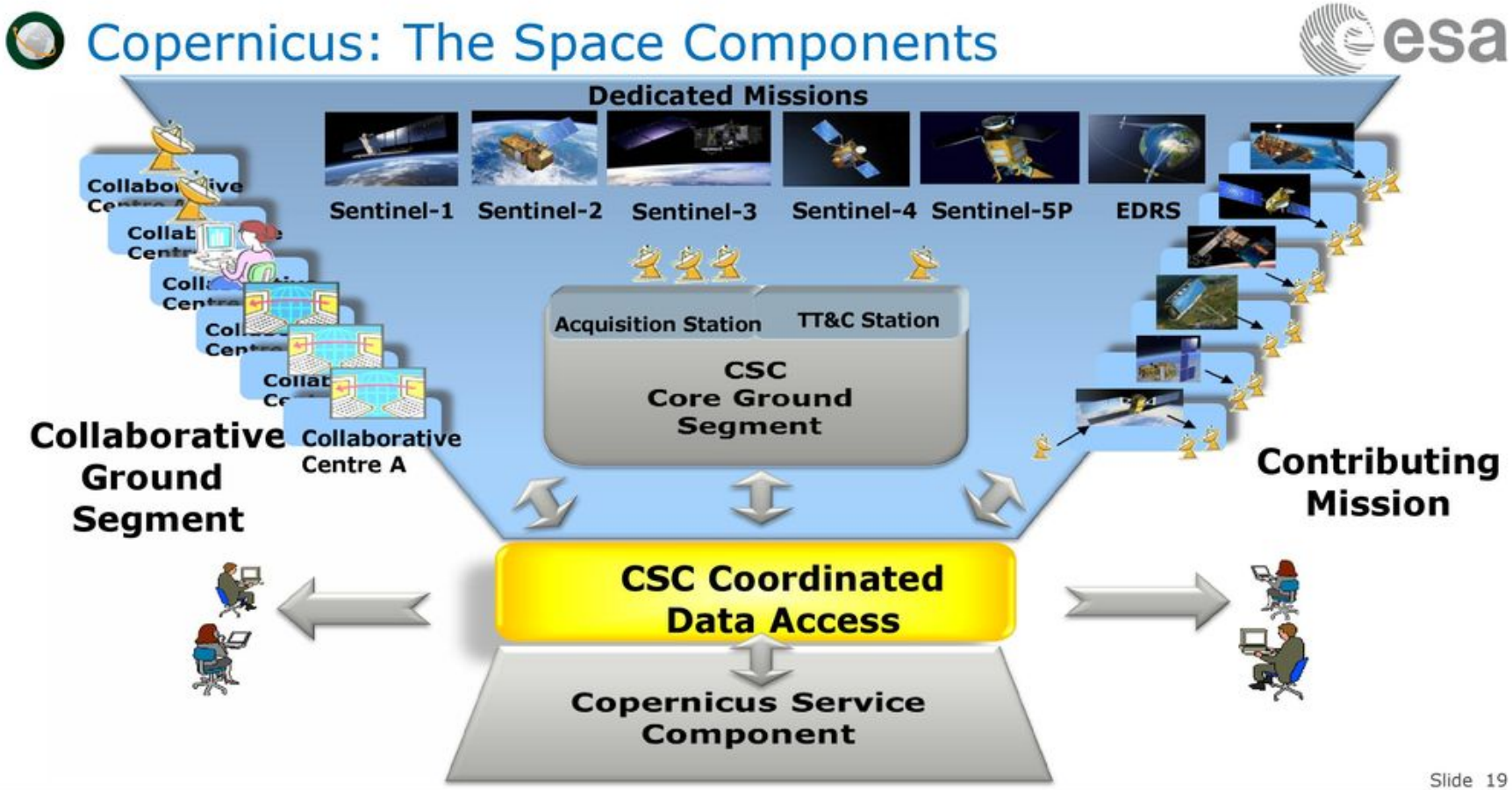
Outline

- Copernicus access Hubs
- National Mirror Sites

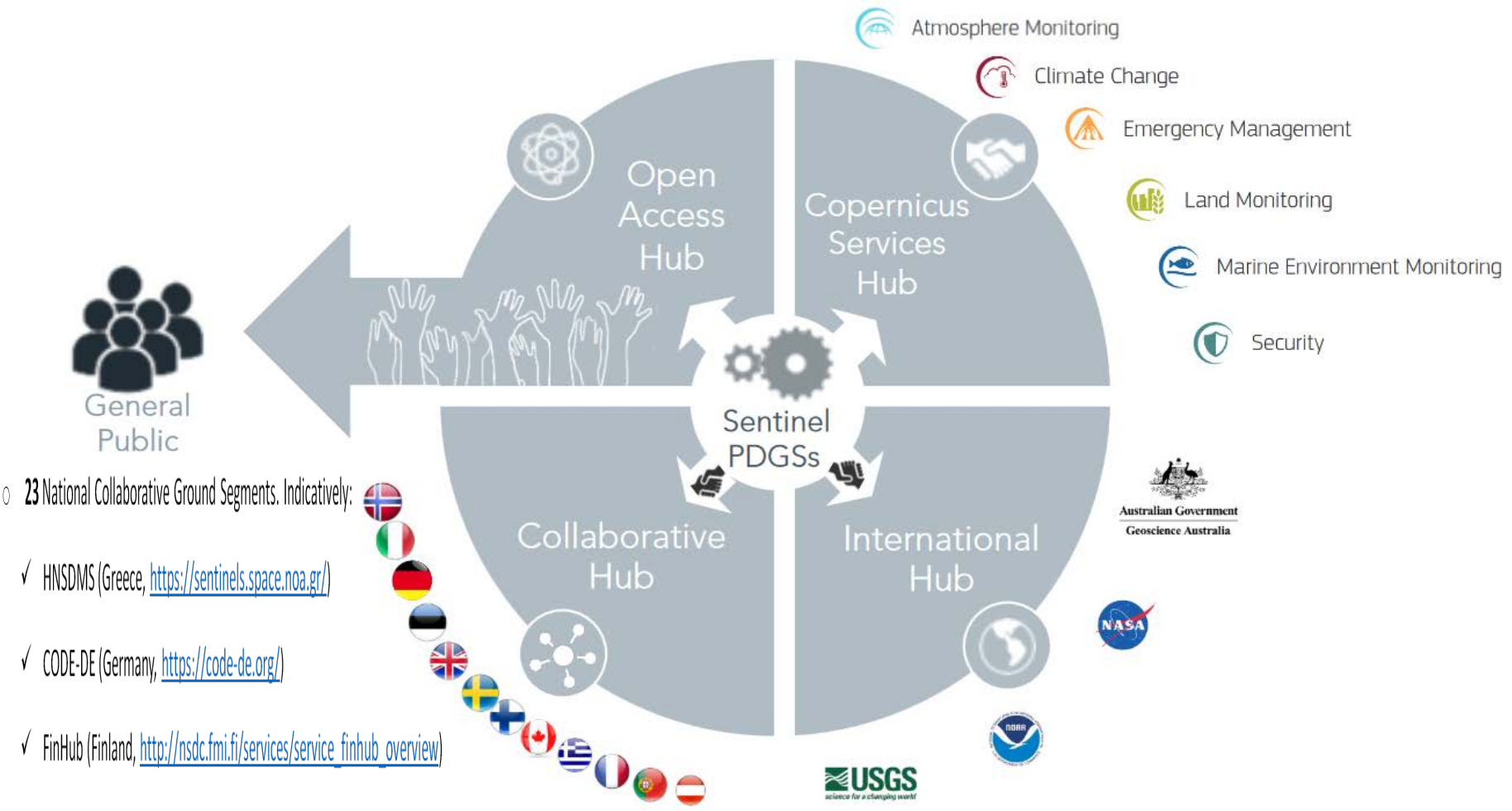
} Fragmented data access

- geObservatory
- Monitoring volcanic activity in Kīlauea, Hawaii

Copernicus Sentinel Data Access

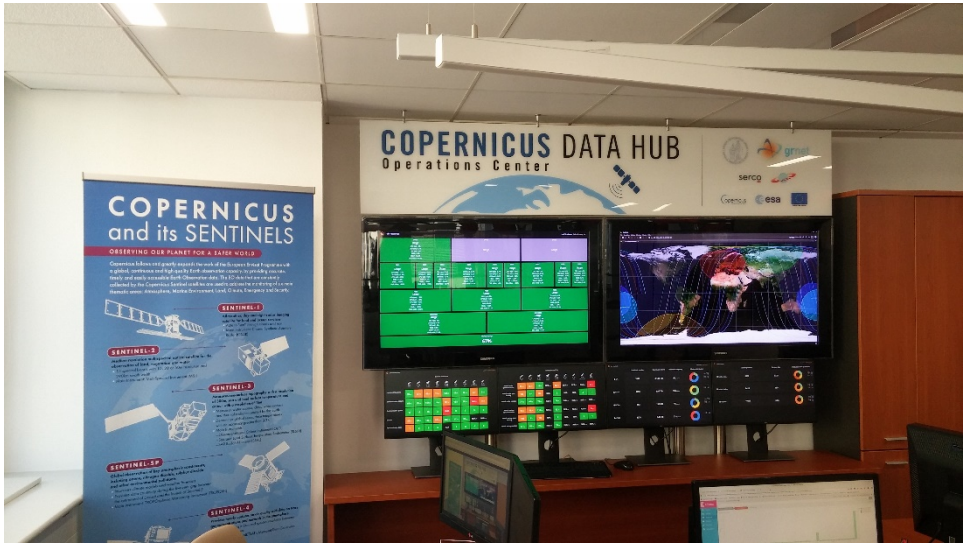


Copernicus Sentinel Data Access



- **23** National Collaborative Ground Segments. Indicatively:
  - ✓ HNSDMS (Greece, https://sentinels.space.noa.gr/)
  - ✓ CODE-DE (Germany, https://code-de.org/)
  - ✓ FinHub (Finland, http://nsdc.fmi.fi/services/service_finhub_overview)
  - ✓ Peps (France, https://peps.cnes.fr/rocket/)

Sentinels Greek Hub | Operations bridge

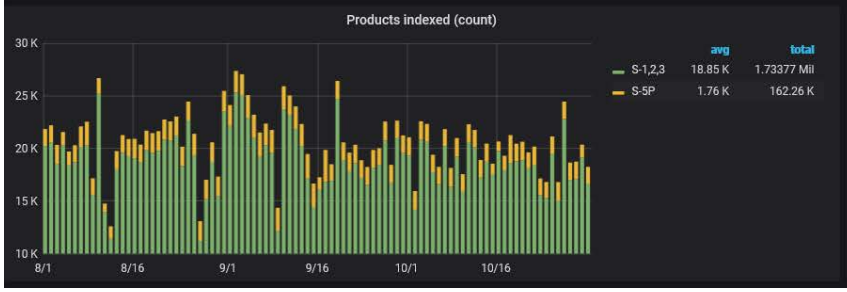


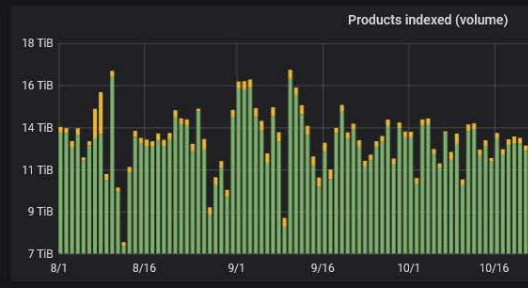
SENTINELS GREEK HUB

Sentinels Greek Hub | Some numbers!

What's coming in

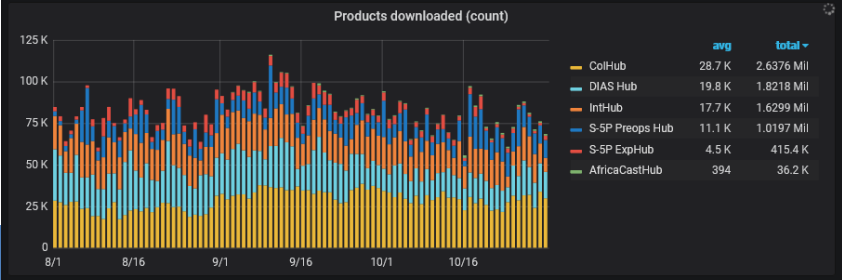
On average:
~20K products (13TiB) / day or
~600K products (390TiB) / month
~2 Gbps

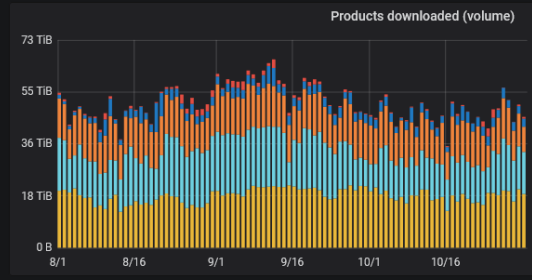




What's going out

On average:
~80K products (50TiB) / day or
~2.5M products (1.5PiB) / month
~6 Gbps





SENTINELS GREEK HUB

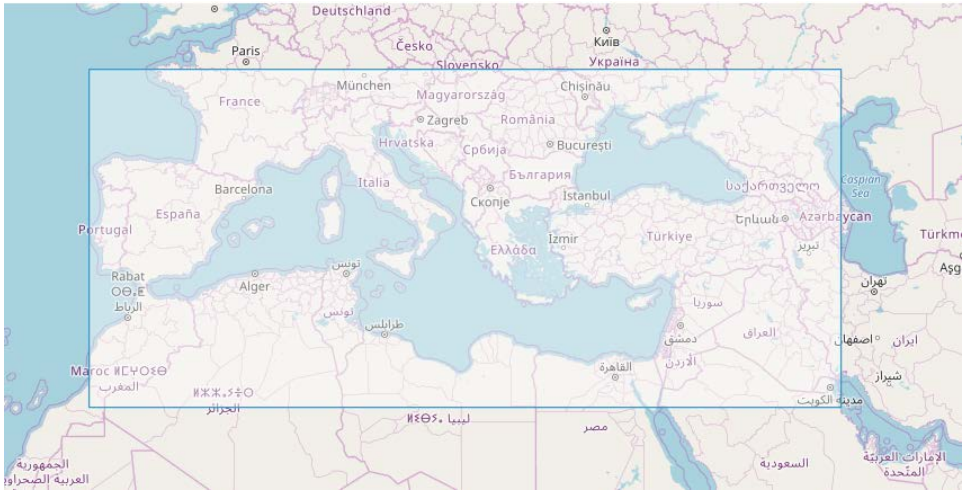
- INTHUB #1
- COLHUB #3
- DIASHUB #3
- AfricaCastHub
- S-5p PreOps Hub
- S-5p Expert Users Hub
- TMPHUB #1
- HNSDMS

58 Virtual Machines:

- **~1 TB RAM**
- **~530 virtual CPUs**
- ~4.5 TB disk storage

A **550 TB** network filesystem for storing > **500 thousand** Sentinel products at any time

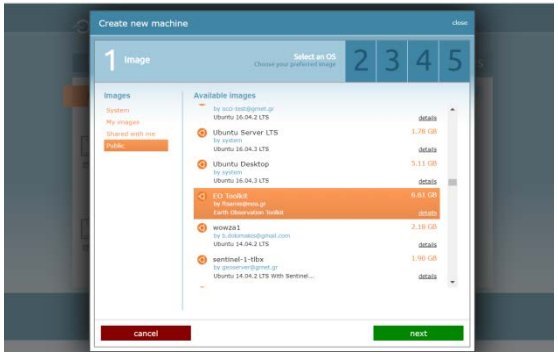
The Greek Mirror Site: https://sentinels.space.noa.gr/



- Mirror Site is running on a high performance VM provided by GRNET
- Synchronizes products with remote copy from ColHub Node 1, 2 & 3 for a specified Area of Interest
- Rolling archive of 30 days using a 44TiB NAS storage

The Greek Mirror Site: https://sentinels.space.noa.gr/

- Shibboleth support for academic user authentication



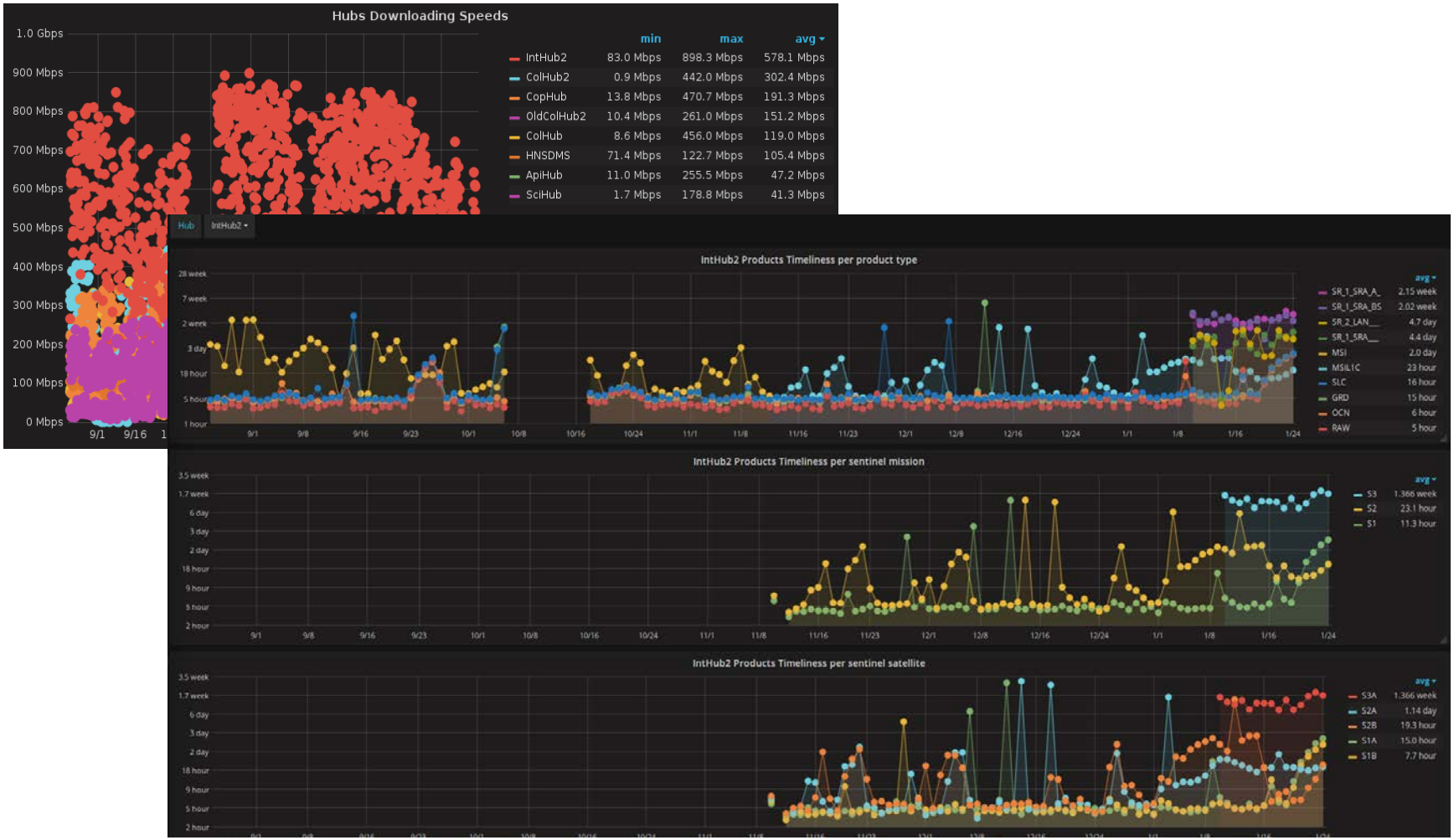
- EO Toolkit Linux image
- Online course for the use of the Mirror Site

- EOSC-hub linked with the Greek Mirror site

Fragmented access to Sentinel data

- The hubs have different data offer
  - Availability of different missions and different products per sensor
  - Geographic coverage within which Sentinel products are available (e.g. see the Greek Collaborative Ground Segment AOI
  - Maximum concurrent downloads allowed
  - Data rolling policy (even SciHub has adopted a rolling policy)
  - Serve different user types
- The hubs experience different performances
  - Downloading speed
  - Integrity
  - Number of published products
  - Response times
  - Availability
  - Product latency
- Even for the same hub there is intra-day, and intra-product variability in terms of KPIs

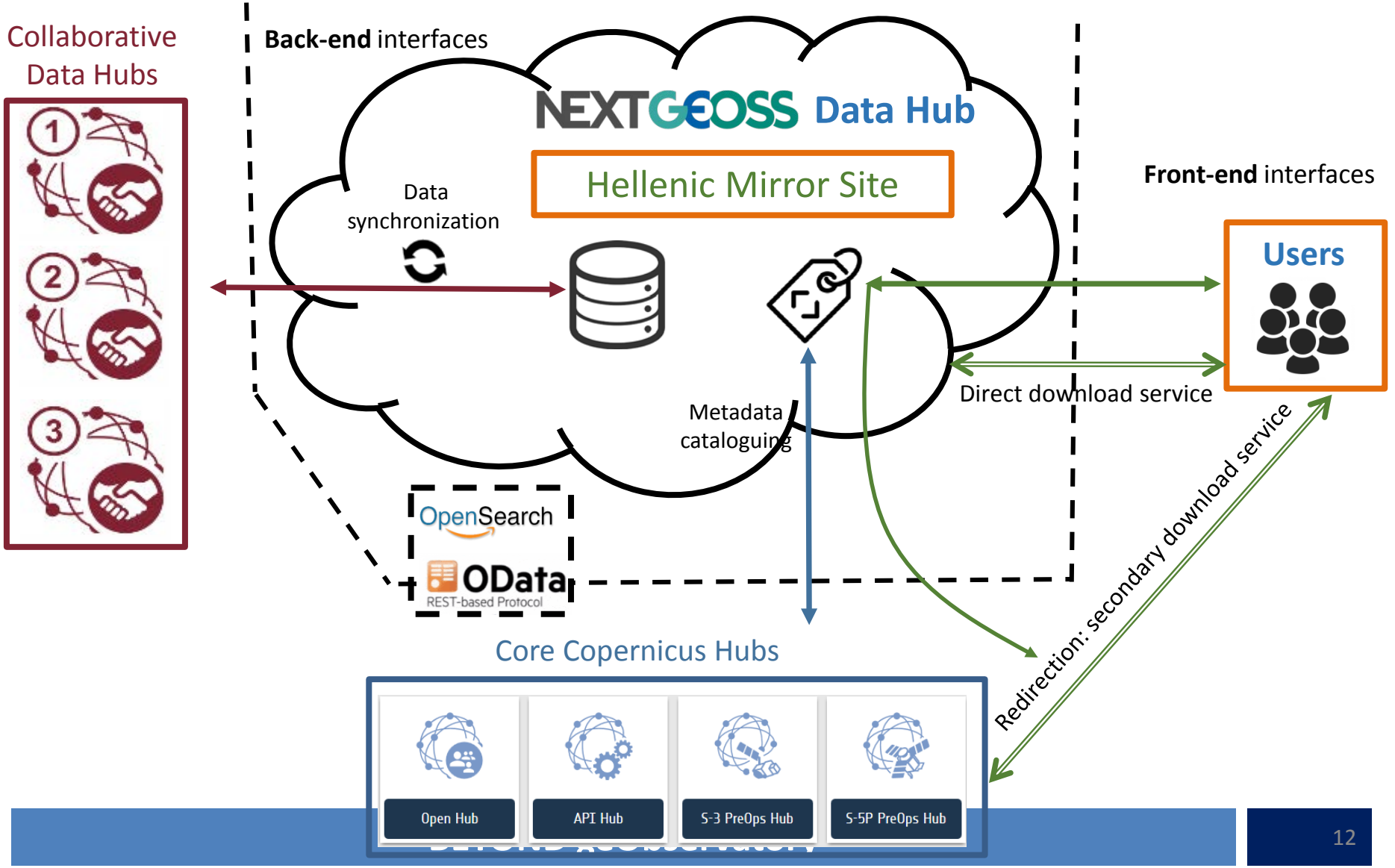
Fragmented access to Sentinel data



Our concept to tackle data fragmentation

- Develop an umbrella application to federate access to Sentinel data
- The application connects in the back-end to most of the available Hubs, but this will be transparent to the user
- The front-end is the common Data Hub Software (DHuS - https://sentineldatahub.github.io/DataHubSystem/):
  - Well-known GUI for the users
  - Incorporates OpenData and OpenSearch APIs
  - DHuS 2.0 just released!

Our concept to tackle data fragmentation



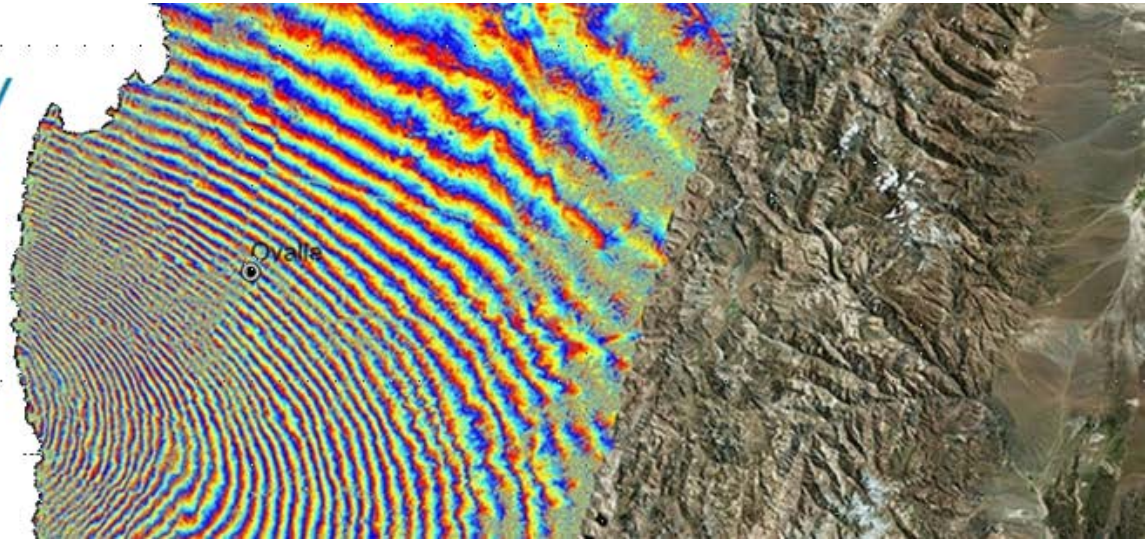
Advantages

- Linking federated Copernicus Sentinels Hubs
- Access to a single hub instead of looking across several Sentinel Hubs to find the appropriate products for your application
- Access to all Sentinel mission data, no geographic restrictions
- Better timeliness and reduced lead times for accessing Sentinel products ------> more important for disaster management applications
- Less performance variability by exploiting Hub diversity

geObservatory

IAASARS

BEYOND



geObservatory | In a nutshell

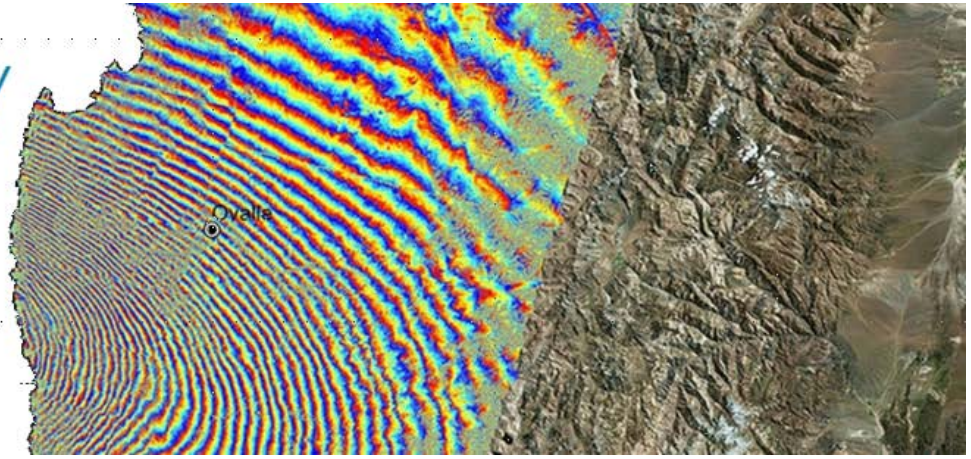
GeObservatory is activated in major geohazard events (earthquakes, volcanic activity, landslides,etc.) and automatically produces a series of Sentinel-1 based co-event interferograms (DInSAR) to map the surface deformation associated with the event.

http://beyond-eocenter.eu/geohub/

geObservatory

IAASARS

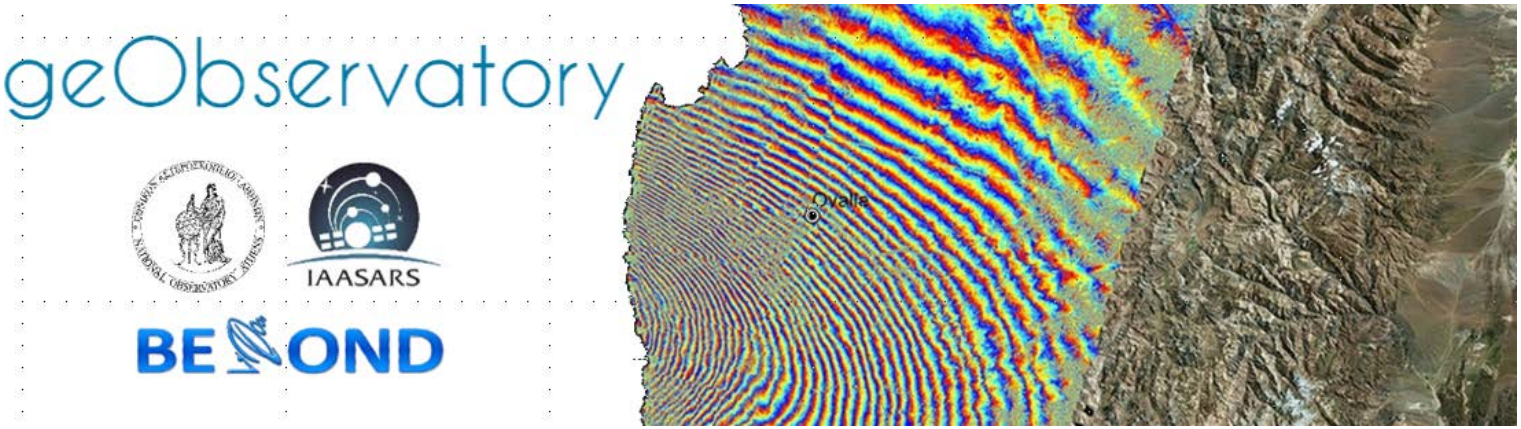
BEYOND



geObservatory | Activation

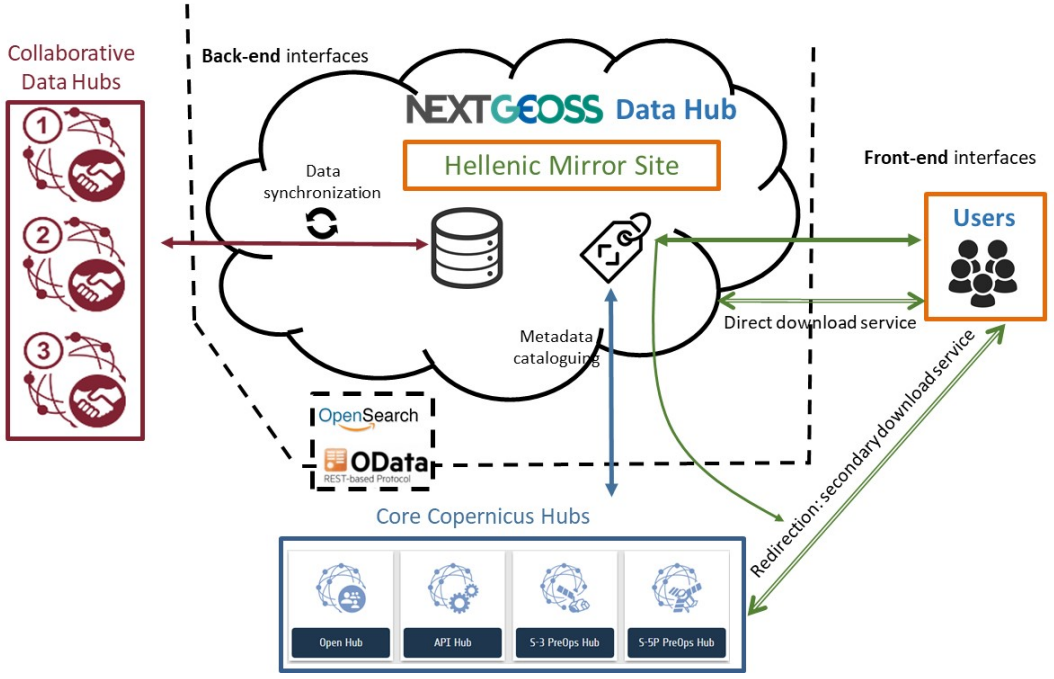
- Manual activation. An authorized user provides to the application a json file delineating the Area of Interest and registering the timestamp of the event.
- Automatic activation. GeObservatory connects to EMSC and is activated when a major earthquake occurs. Criteria for the activation of GeObservatory is the magnitude of the earthquake and its depth.

http://beyond-eocenter.eu/geohub/

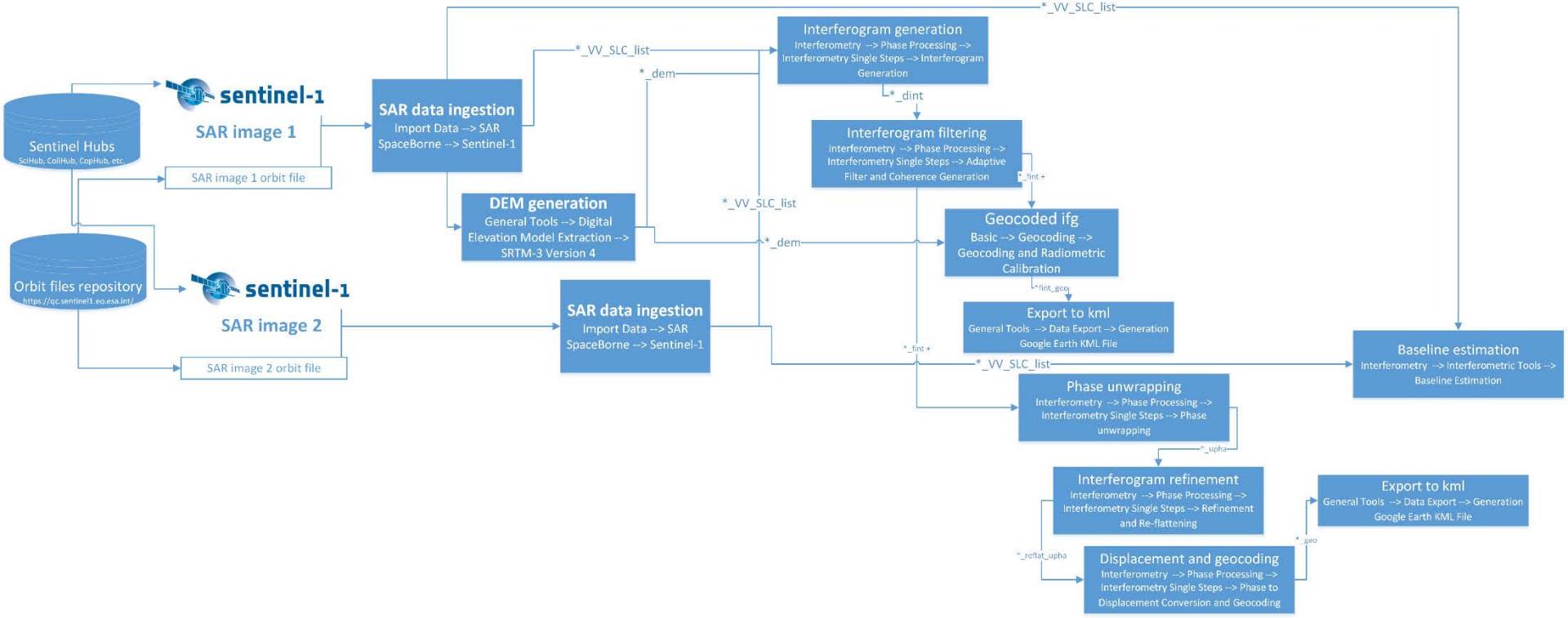


geObservatory | Input data

After the system is triggered, the application automatically scans different Copernicus hubs, including the Greek Collaborative Ground Segment, to find the appropriate Sentinel-1 satellite data for interferometry.



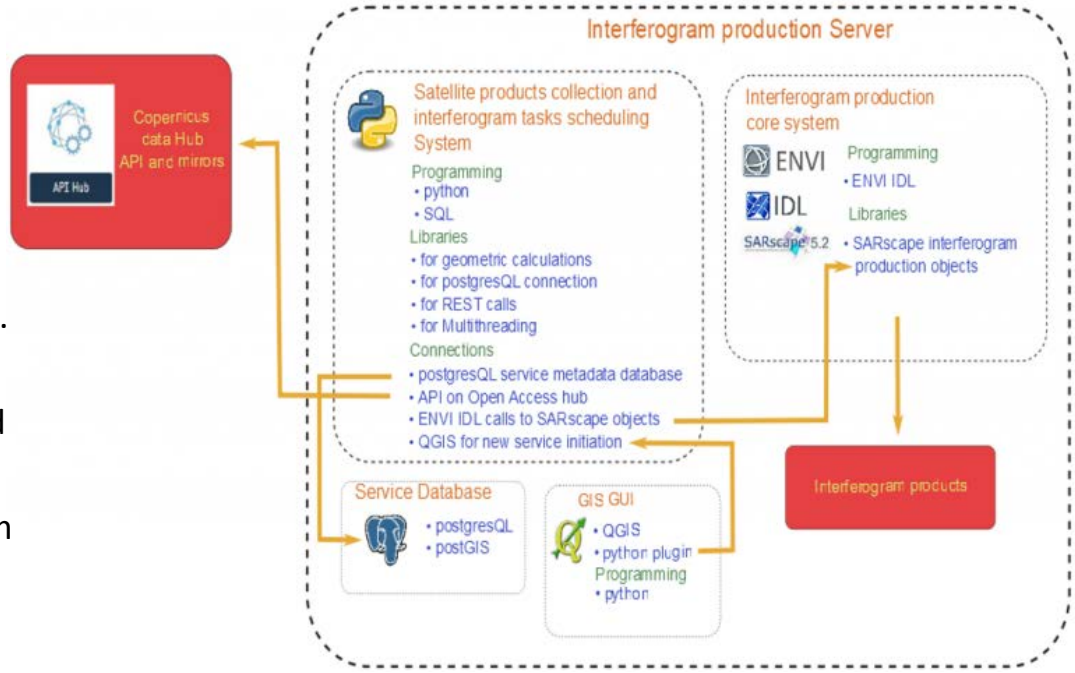
geObservatory | Interferometric processing



geObservatory | Application orchestrator

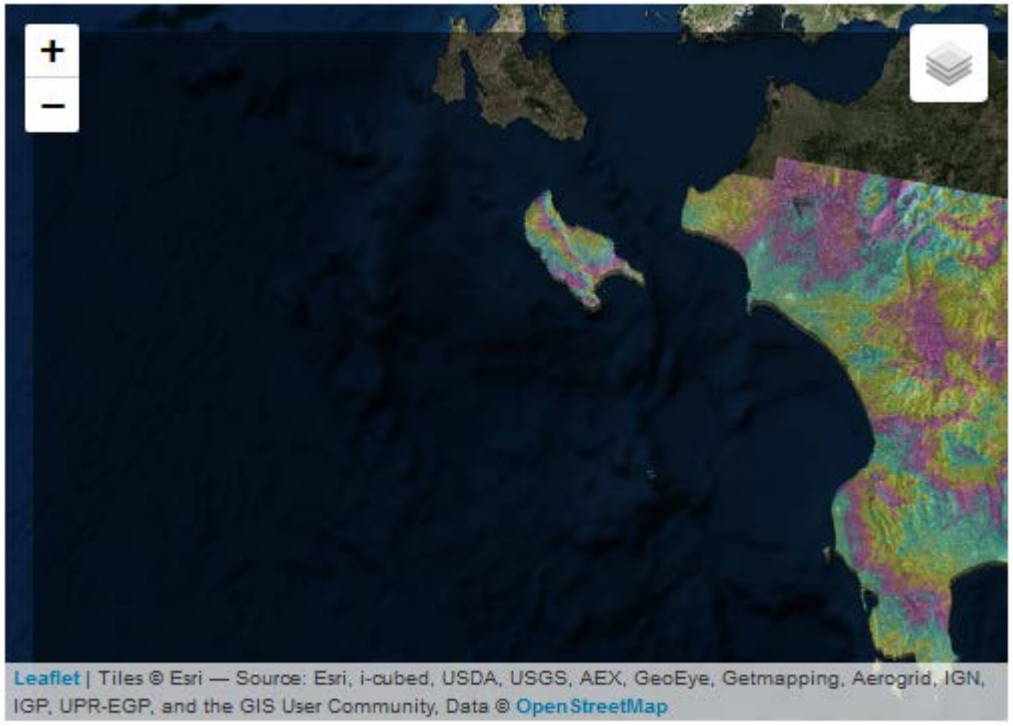
Application server which orchestrates the enter service are:

- The “Products collection and Task scheduling service” written in python. This program initiates the request processing, finds and downloads the necessary satellite inputs and controls the output production tasks. A QGIS plugin has also been developed to manual trigger GeObservatory through a user interface.
- The Service Metadata Database (postgresql) that contains processing information, input and output metadata
- The ENVI SARscape module is the interferogram production engine. The “Products collection and Task scheduling service” execute commands from ENVI sarscape module using IDL scripts in order to create the interferograms
- The IDL scripts that execute the main interferogram tasks calling the sarscape commands.

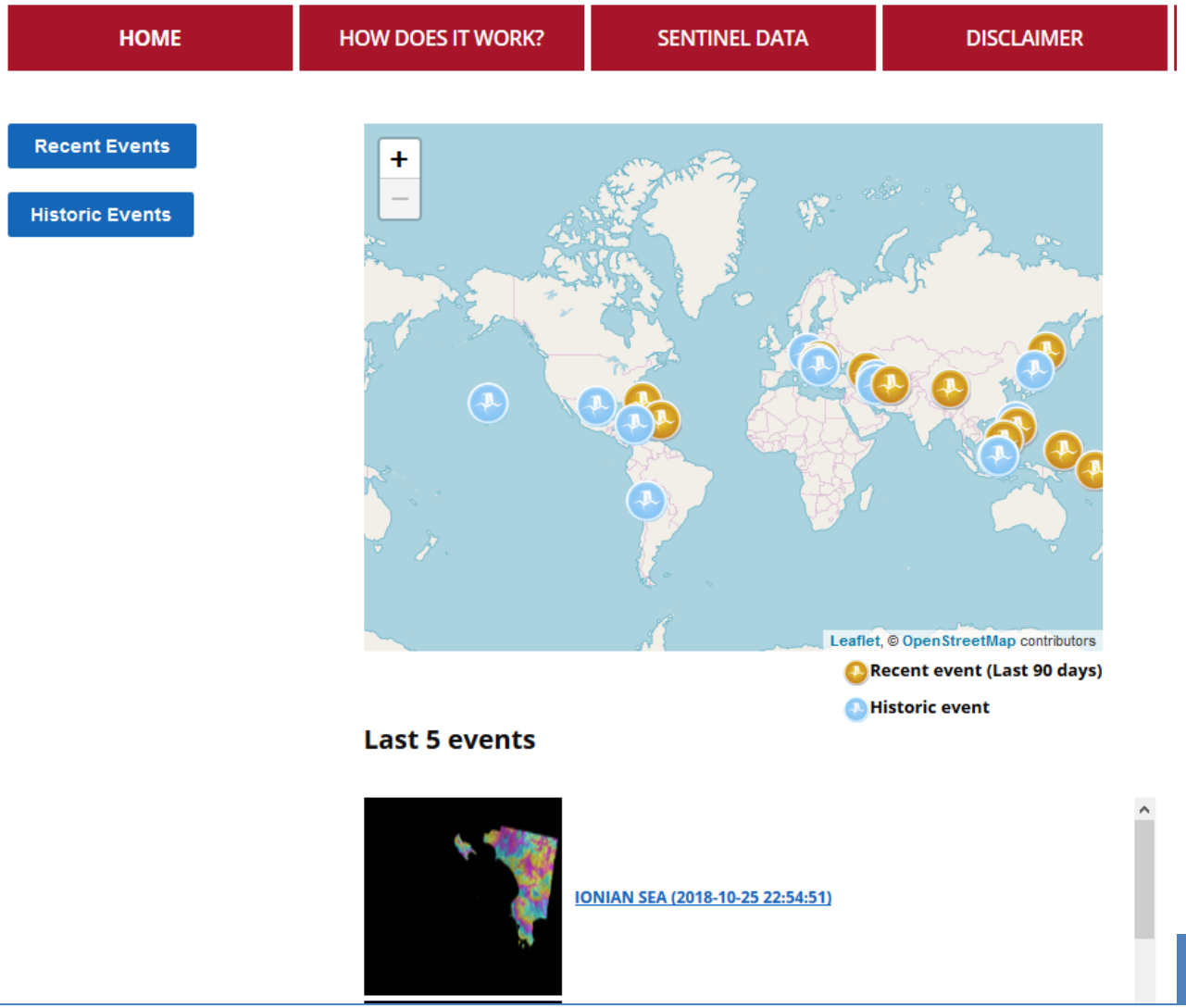


geObservatory | Interferograms

- High resolution tiff available for download
- Quicklook interferogram in PNG
- Online viewing using Leaflet technology

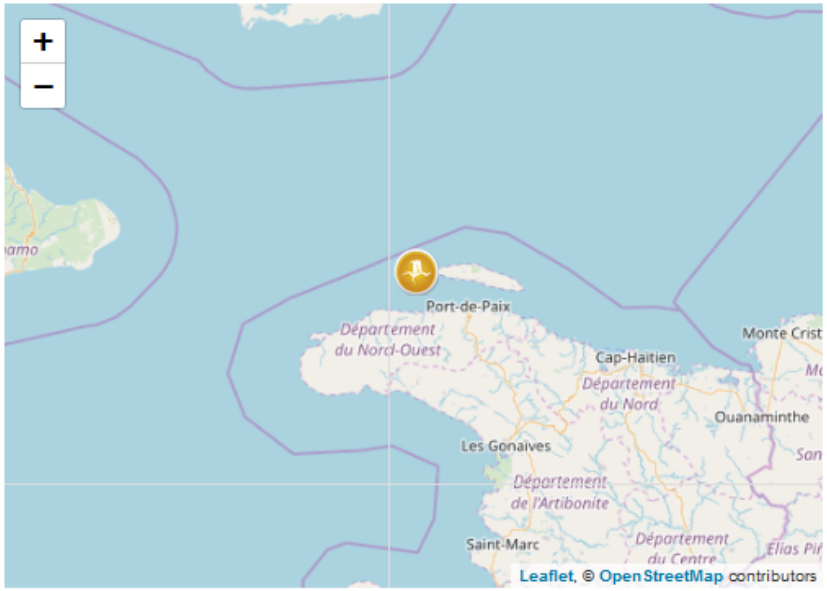


geObservatory | Front-end

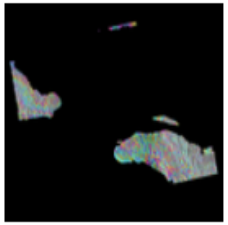


HAITI REGION (2018-10-07 00:11:48)

Earthquake location: HAITI REGION
Magnitude: 5.8
Depth: 10 km
Time: 2018-10-07 00:11:48
Coordinates: 19.98 , -73.03



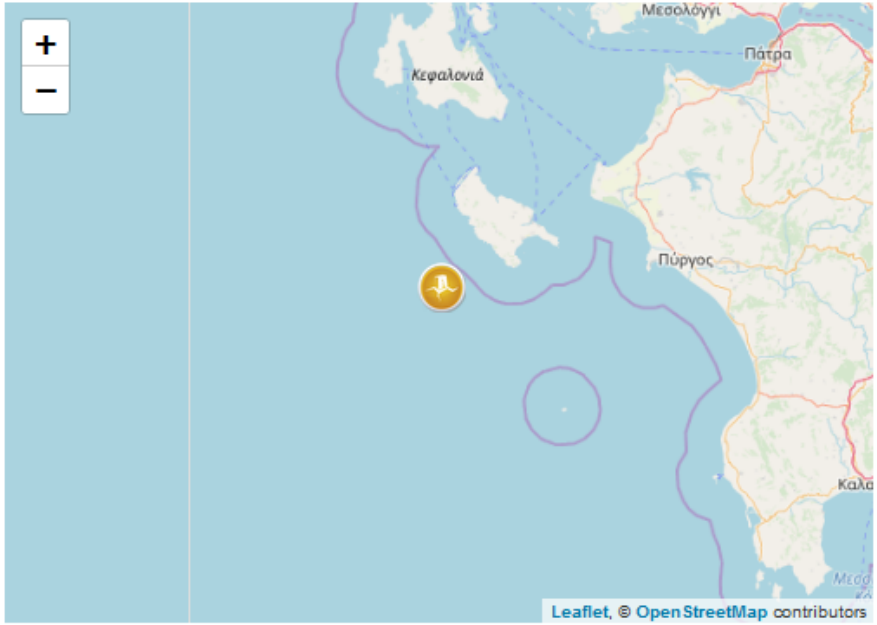
Interferograms



Type: co-seismic
Master: 2018-09-26 23:01:42
Slave: 2018-10-08 23:01:42
Orbit Number: 4
Mode: ASCENDING
Download (TIF) Download (Low Resolution) Preview

IONIAN SEA (2018-10-25 22:54:51)

Earthquake location: IONIAN SEA
Magnitude: 6.6
Depth: 10 km
Time: 2018-10-25 22:54:51
Coordinates: 37.52 , 20.57

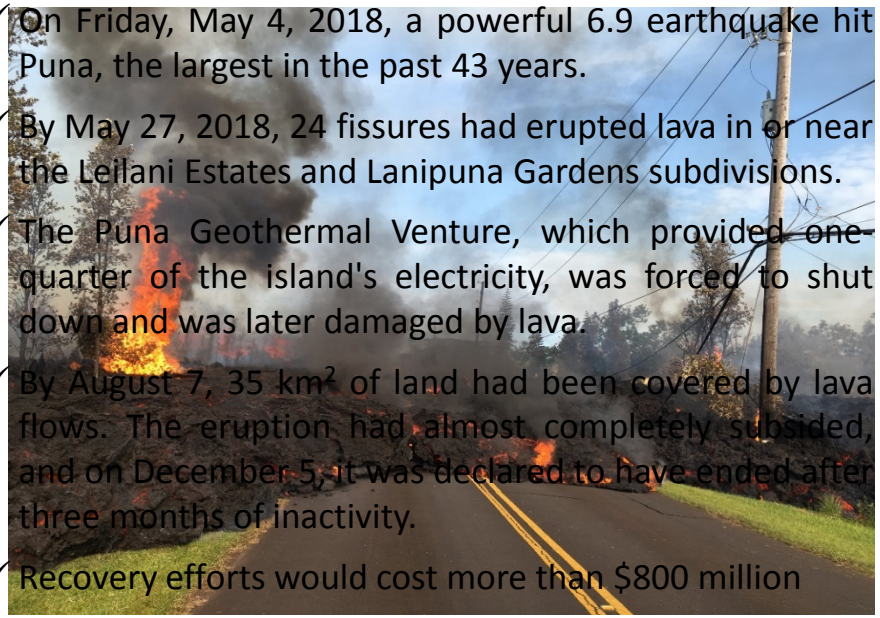


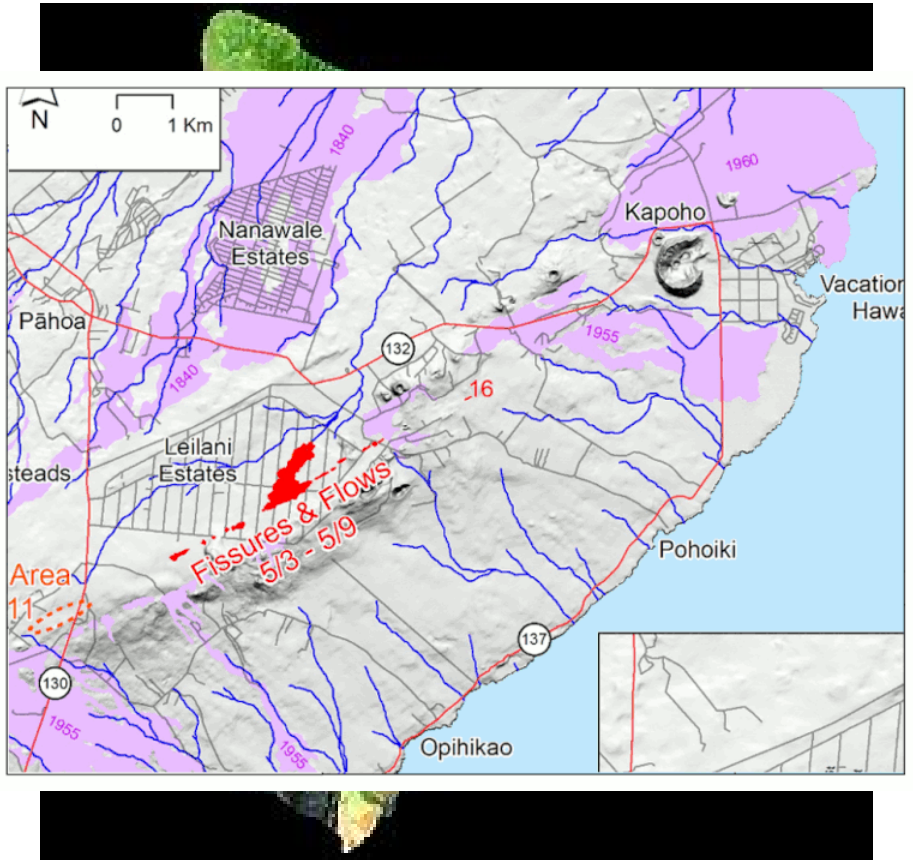
Interferograms

Type: co-seismic
Master: 2018-10-20 04:39:26
Slave: 2018-10-26 04:40:08
Orbit Number: 80
Mode: DESCENDING
Download (TIF) Download (Low Resolution) Preview

geObservatory | Kīlauea volcano, Hawaii

- ✓ Intense micro-seismic activity in the wider area of the Kīlauea volcano in Hawaii occurred during 26/4-2/5/2018.
- ✓ Suddenly, on Thursday 3/5 a volcanic crack appeared near the road network in lower Puna region, from which lava and hot steam appeared. The Civil Protection instructed residents of the Puna community (~10,000) to leave their homes immediately.
- ✓ On Friday, May 4, 2018, a powerful 6.9 earthquake hit Puna, the largest in the past 43 years.
- ✓ By May 27, 2018, 24 fissures had erupted lava in or near the Leilani Estates and Lanipuna Gardens subdivisions.
- ✓ The Puna Geothermal Venture, which provided one-quarter of the island's electricity, was forced to shut down and was later damaged by lava.
- ✓ By August 7, 35 km² of land had been covered by lava flows. The eruption had almost completely subsided, and on December 5, it was declared to have ended after three months of inactivity.
- ✓ Recovery efforts would cost more than $800 million





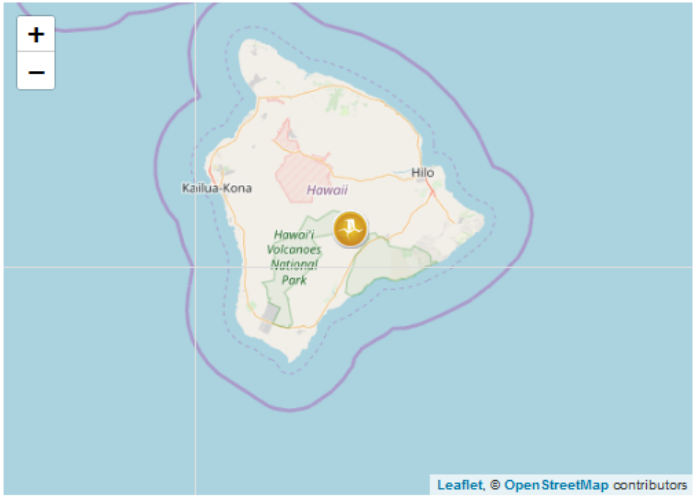
Source: USGS

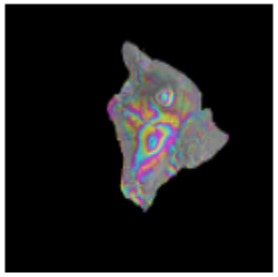
geObservatory | Kīlauea volcano, Hawaii

✓BEYOND responded immediately and activated the geObservatory

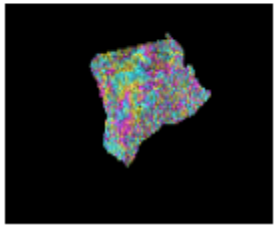
ISLAND OF HAWAII, HAWAII (2018-05-04 22:32:57)

Earthquake location: ISLAND OF HAWAII, HAWAII
Magnitude: 6.5
Depth: 30 km
Time: 2018-05-04 22:32:57
Coordinates: 19.39 , -155.41





Type: co-seismic
Master: 2018-04-23 16:15:24
Slave: 2018-05-05 16:15:25
Orbit Number: 87
Mode: DESCENDING
Download (TIF) Download (Low Resolution) Preview



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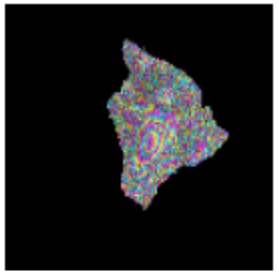
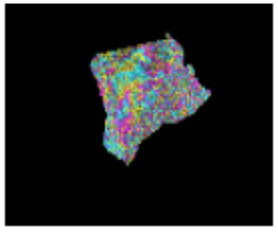
Slave: 2018-05-08 04:29:48
Orbit Number: 124
Mode: ASCENDING

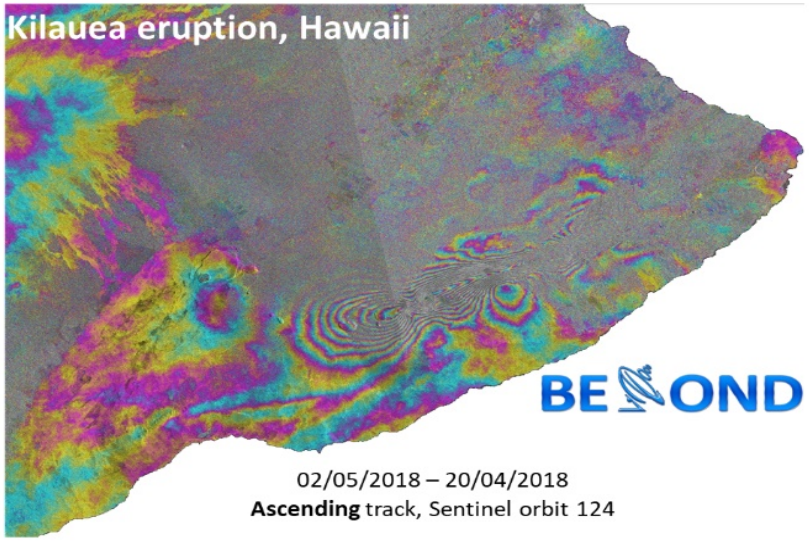


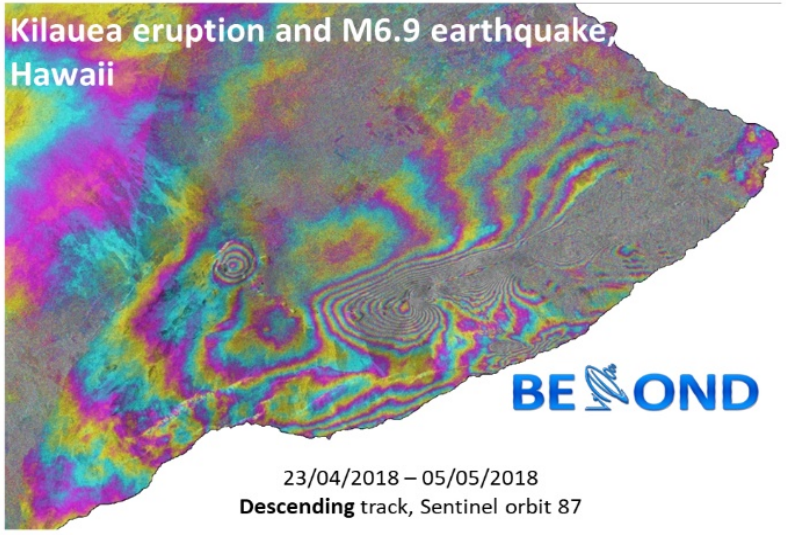
Type: pre-seismic
Master: 2018-04-23 16:15:24
Slave: 2018-04-11 16:15:24
Orbit Number: 87
Mode: DESCENDING
Download (TIF) Download (Low Resolution) Preview



Type: pre-seismic
Master: 2018-05-02 04:30:26
Slave: 2018-04-20 04:30:26
Orbit Number: 124
Mode: ASCENDING

geObservatory | Kīlauea volcano, Hawaii

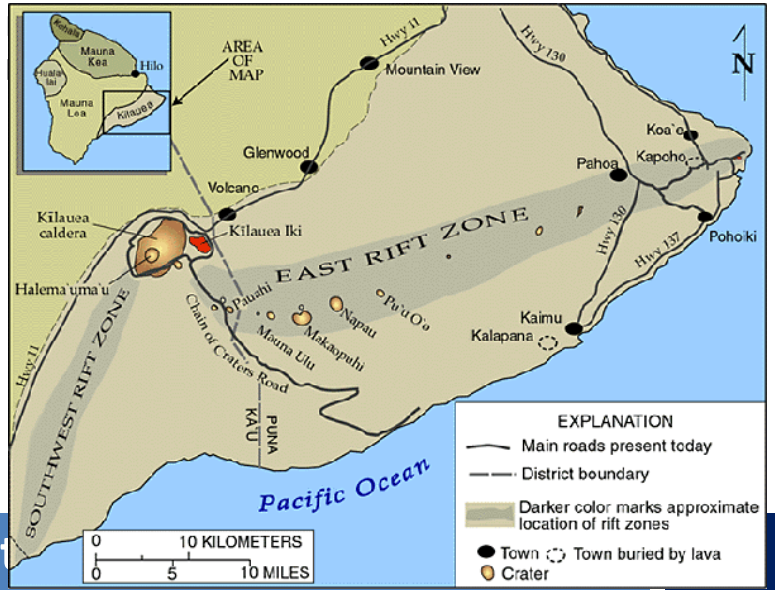




IFG #1: Covers only the pre-earthquake volcanic eruption period.

→ Intense subsidence at the top of the volcano as magma material moves along the East Rift Zone and escapes to the eastern edge of the fault. The maximum deformation along this zone, located between the top of the volcano and the area where the lava was firstly observed, is approximately 60-70 cm.

Source: USGS



geObservatory | Remark and future work

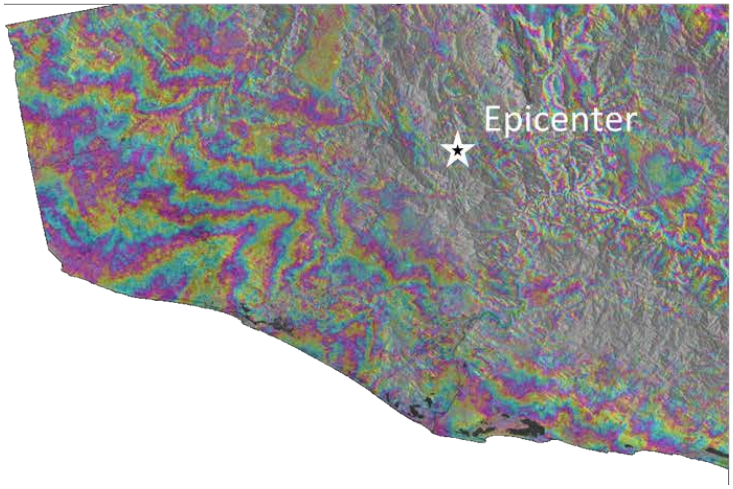
- 25 activations of geObservatory in 2018
- GeObservatory is a beta version application which is supported by the BEYOND team on a best effort basis.
- The interferometric products are generated on a fully automatic approach, without an intervention of an expert.
- Future functionalities:
  - Continuous monitoring of critical sites
  - Notification service through registration
  - Processing on the cloud, GPU enabled
  - Automatically decompose products to east-west and up-down vectors by combining descending & ascending imagery
  - Add 3rd party SAR mission data

THANK YOU FOR YOUR ATTENTION

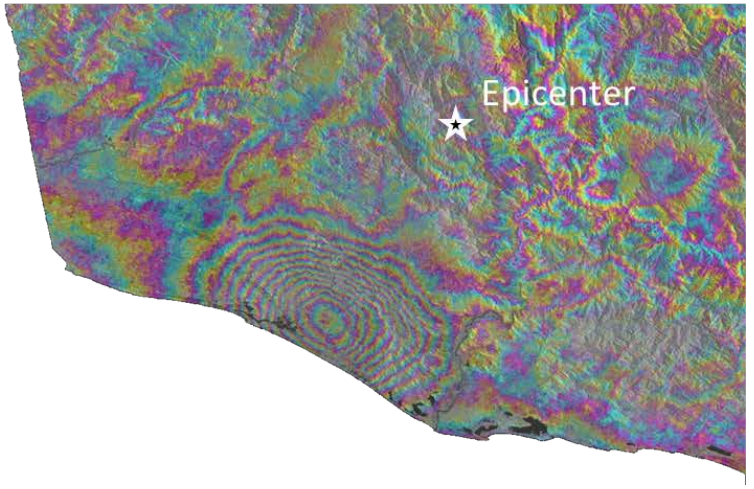
geObservatory | Example

Mexico EQ, Mw7.2 16/02/2018 23:39 UTC

Pre-seismic interferogram
05/02/2018 – 13/01/2018
Ascending
Normal baseline: 71 m
Altitude of ambiguity: 217 m
Sentinel orbit 5



Co-seismic interferogram
05/02/2018 – 17/02/2018
Ascending
Normal baseline: -9 m
Altitude of ambiguity: 1643 m
Sentinel orbit 5



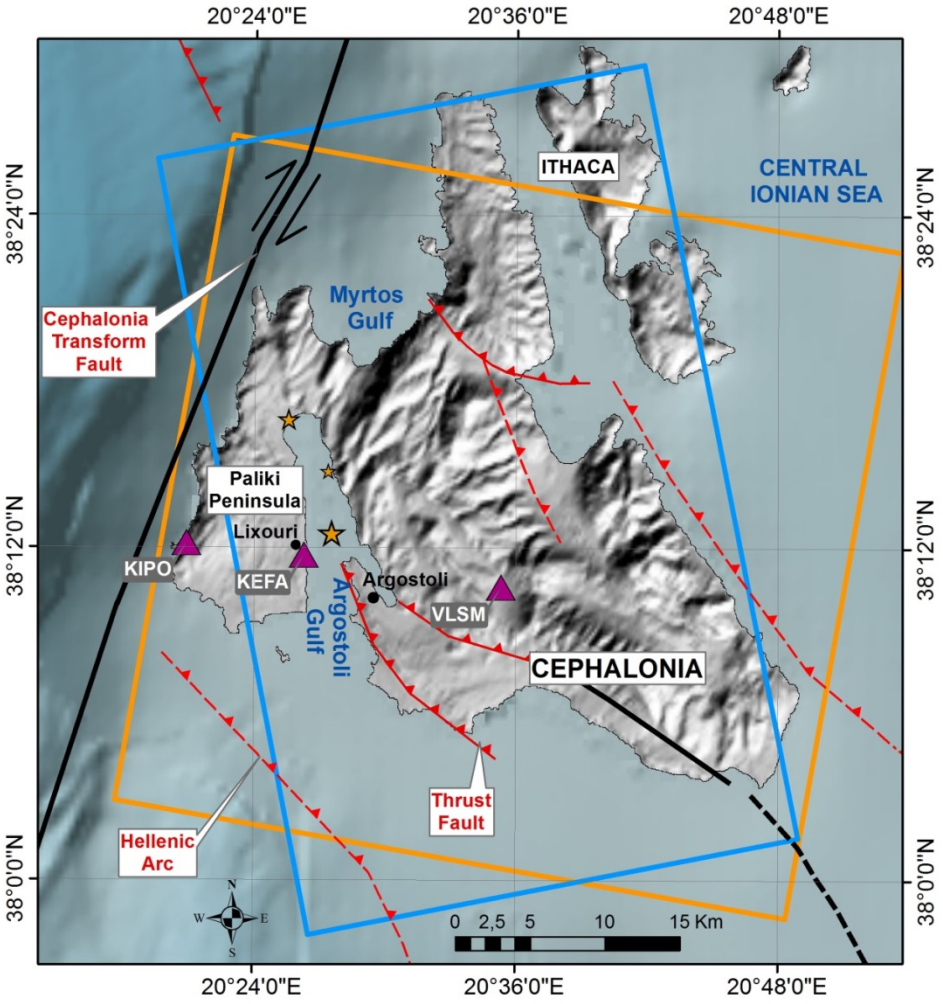
GeoHUB: Earthquake deformation mapping

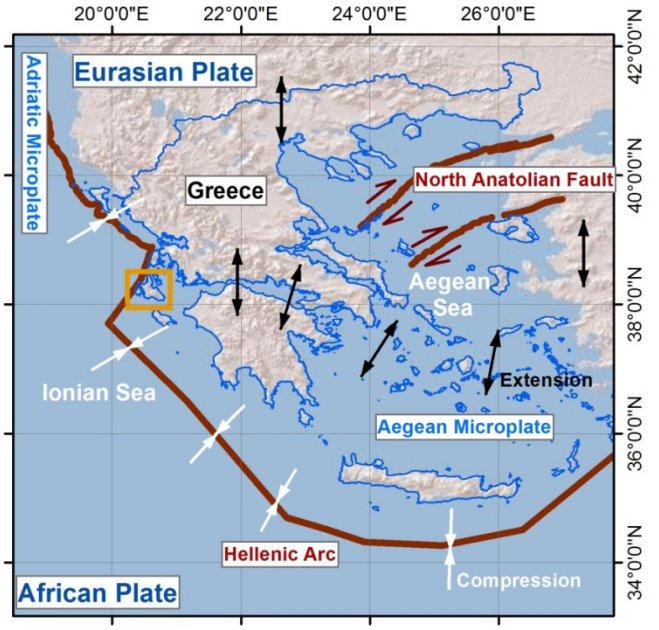
Merryman Boncori et al., SRL 2015

Data
- NSN
- NOANET
- ENIGMA
- In-situ

Services
- Geodesy
- Modeling
- Hazard Ass.
- Large Proc.

Applications
- Tectonics
- Volcanoes
- Landslides
- Subsidence

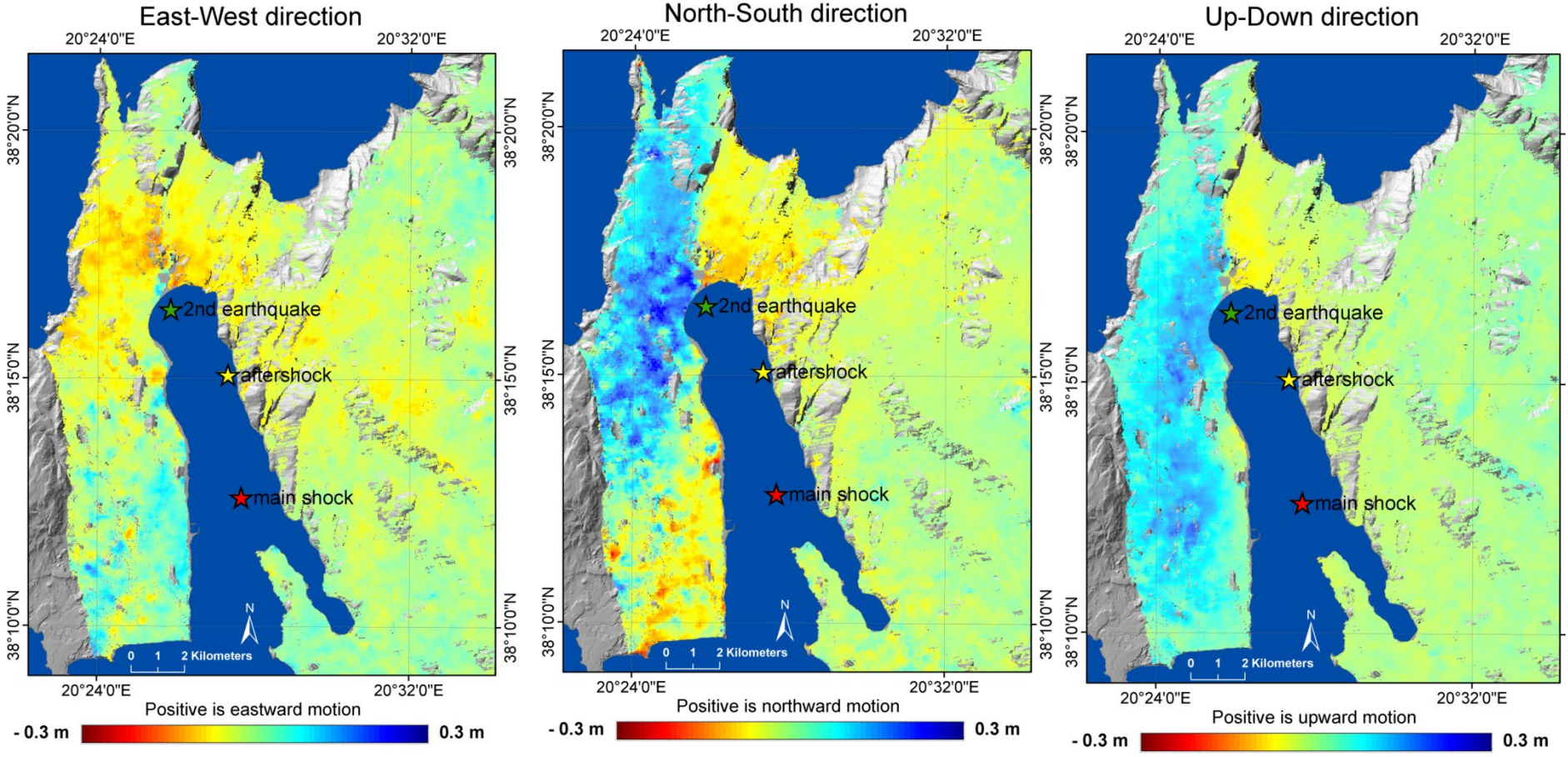




GeoHUB: Earthquake deformation mapping

- 3D crustal deformation from TerraSAR-X & COSMO-SkyMed data
- Inversion to estimate fault parameters

Merryman Boncori et al., SRL 2015



GeoHUB: Earthquake deformation mapping

Italian earthquakes in 2016/2017

Papadopoulos et al., Pure and Applied Geophysics, 2017

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- ENIGMA
- In-situ

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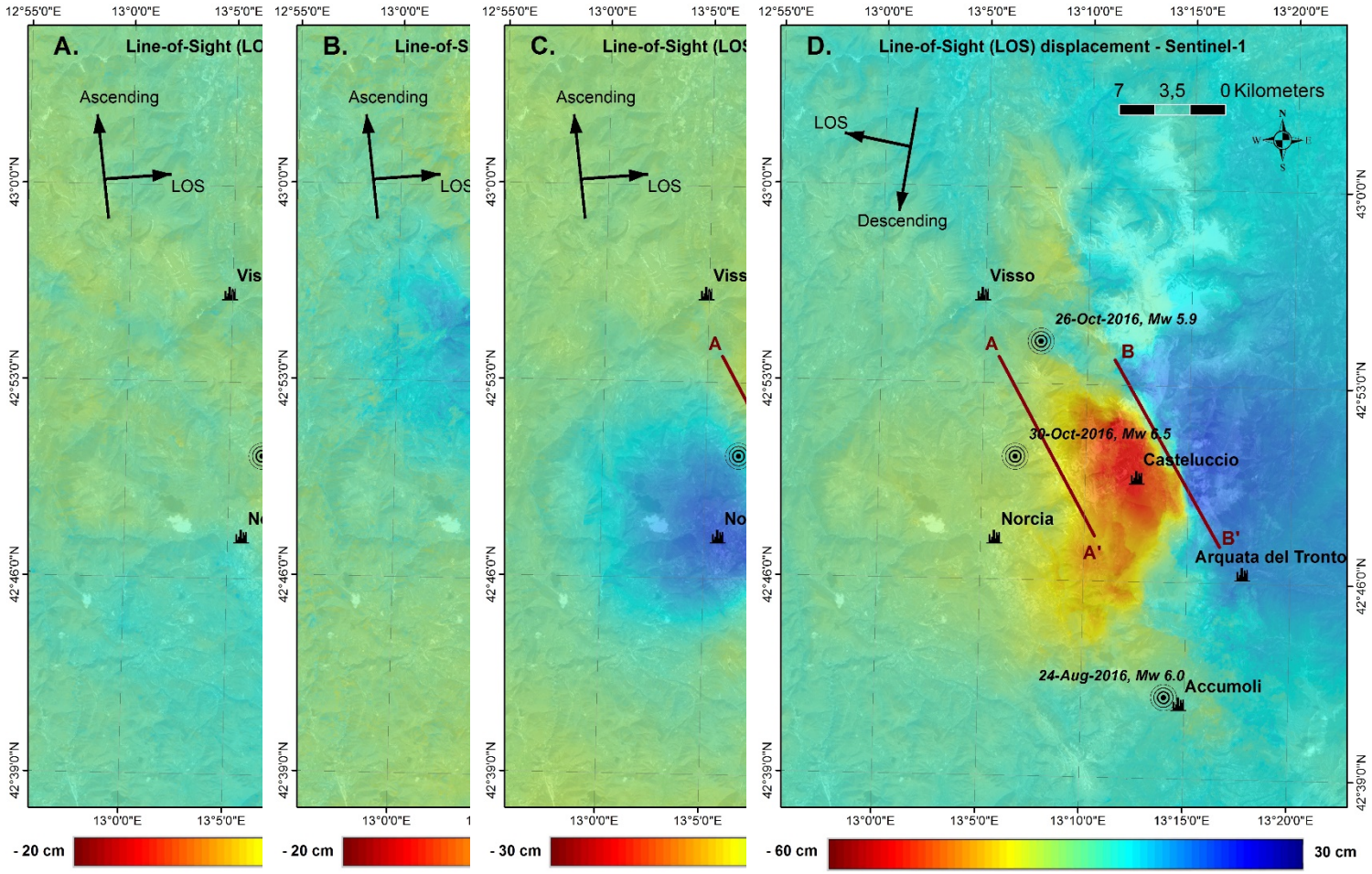

GeoHUB: Earthquake deformation mapping

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